Vol. XI. JULY, 1895. No. 3.

JOURNAL

OF THE

New-York Microscopical Society

EDITED BY

REV. J. L. ZABRISKIE,

28 REGENT PLACE, FLATBUSH STATION, BROOKLYN, N. Y.

CONTENTS.

	PAGE.
I. Interesting Features of well-known Plants of New-York Harbor. By CARLTON C. CURTIS (Plates 50, 51)	63
II. The relation of Aperture to the determination of Minute Structure. By CHARLES F. COX	74
III. Proceedings	86

New-York:

PUBLISHED FOR THE SOCIETY,

QUARTERLY.

PRESS OF DOUGLAS TAYLOR & CO.
No. 8 WARREN STREET.
1895.

[Entered at the Post-Office at New-York as second-class matter.]

New-York Microscopical Society.

OFFICERS FOR THE YEAR 1895.

President, – – – – – – – – – – – – EDWARD G. LOVE.
Vice-President, – – – – – – – – – – – FRANK D. SKEEL.
Treasurer, – – – – – – – – – – – – JAMES WALKER.
Recording Secretary, – – – – – – – – – – GEORGE E. ASHBY.
Corresponding Secretary, – – – – – – – – – – J. L. ZABRISKIE.

Committee on Admissions.

HENRY C. BENNETT, GEORGE H. BLAKE, THOMAS S. NEDHAM, FREDERICK KATO, W. J. LLOYD.

Committee on Publications.

J. L. ZABRISKIE, FRANK D. SKEEL, GEORGE W. KOSMAK, EDWARD G. LOVE, H. A. PARMENTIER.

Regular Meetings on the first and third Fridays of each month, from October to June, inclusive, at 8 P. M., at No. 64 Madison Avenue, New-York City.

JOURNAL

—OF THE—

NEW-YORK MICROSCOPICAL SOCIETY

CONTAINING ITS TRANSACTIONS AND PROCEEDINGS.

PUBLISHED QUARTERLY.

All communications for the JOURNAL, all subscriptions, and all exchanges, should be addressed to the editor, REV. J. L. ZABRISKIE, 28 Regent Place, Flatbush Station, Brooklyn, N. Y.

Terms of Subscription:—In the United States, Canada and Mexico, One Dollar per annum, beginning with the January number. In other countries, One Dollar and Twenty-five Cents per annum.

F. W. DEVOE & CO.,

(ESTABLISHED IN 1852.)

Fulton Street, corner of William Street,

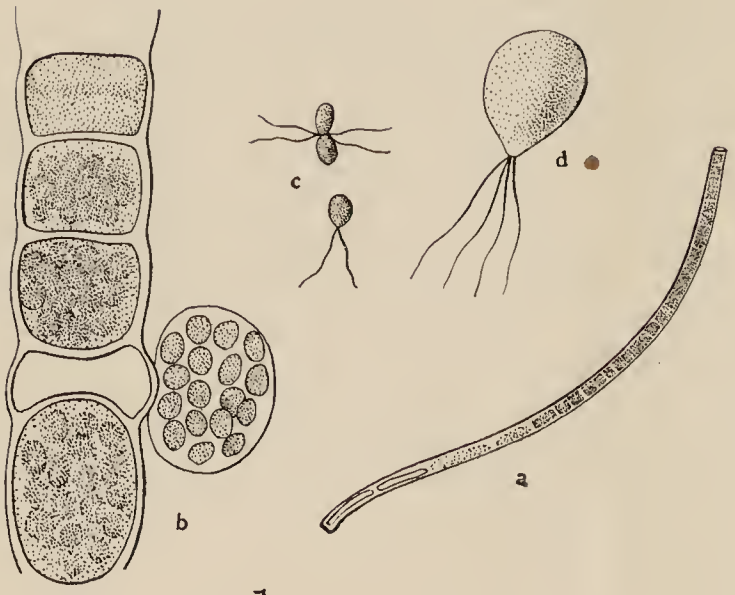
NEW YORK.

ARTISTS' MATERIALS,

OF ALL KINDS,

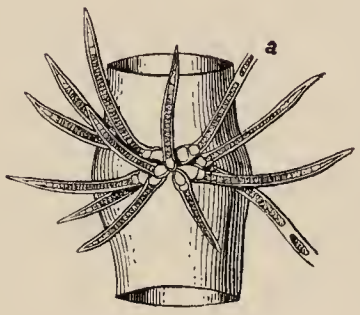
FINE BRUSHES, MATHEMATICAL INSTRUMENTS,

COLORS, VARNISHES.



1

2



3

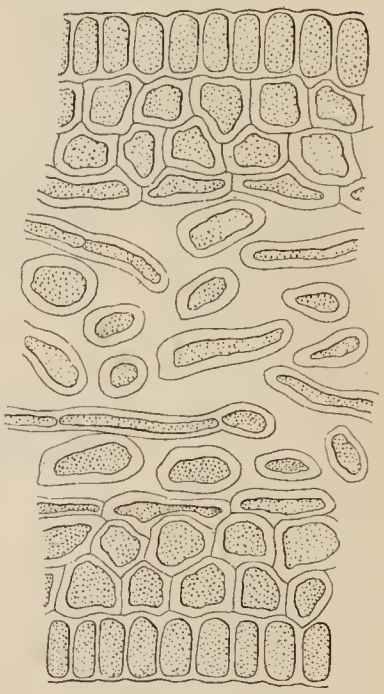
4

CURTIS ON ALGÆ.

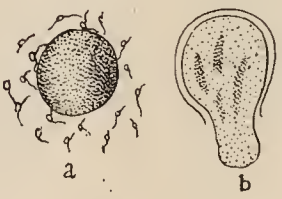
Digitized by the Internet Archive
in 2019 with funding from
Wellcome Library

https://archive.org/details/s962id11784170

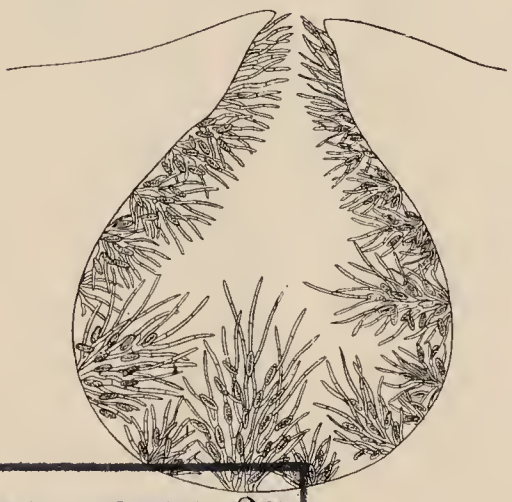
1



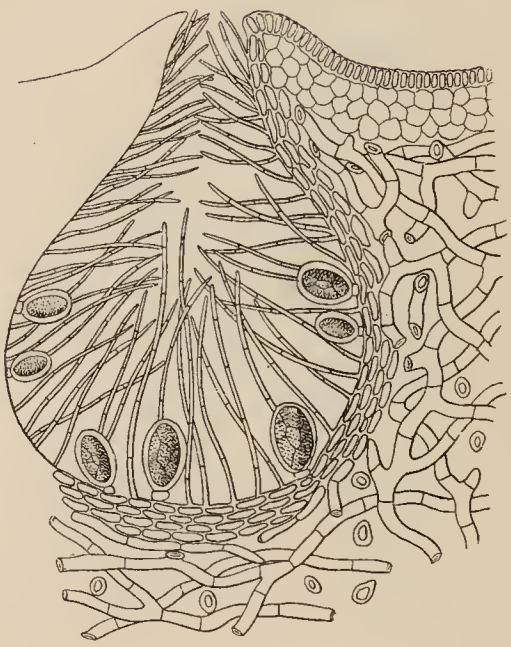
2



5



3



4

WELLCOME INSTITUTE LIBRARY
Coll. WelMOmec
Coll. No.

CURTIS ON ALGÆ.

JOURNAL

OF THE

NEW-YORK MICROSCOPICAL SOCIETY.

VOL. XI. JULY, 1895. No. 3.

SOME INTERESTING FEATURES OF WELL-KNOWN PLANTS OF NEW-YORK HARBOR.

BY CARLTON C. CURTIS, PH.D.

(*Delivered May 17th, 1895.*)

I trust that the discussion of this paper may be of interest to the members of this Society, for especially to the microscopist should the Science of Botany be full of attractions. There is a very prevalent feeling abroad that the study of Botany is of little practical importance compared with other subjects, that the results yielded are not in keeping with those

---

Explanation of Plate 50.

FIG. 1.—*a*. *Ulothrix flacca* (Dillw.) Thuret. The basal portion of an old filament. × 45. *b*. A few cells enlarged, showing escape of zoospores. × 190. *c*. Zoospores, showing their development as gametes in the first stages of conjugation. *d*. Zoospore. The early stage in its development has been indicated in the upper cell in *b*. × 190.

FIG. 2.—*a*. *Ectocarpus littoralis* Lyngb. Upper portion of a branching filament. Some of the cells are enlarged by the formation of unilocular sporangia. × 30. *b*. A portion of a filament with a plurilocular sporangium. × 45. *c*. Zoospores.

FIG. 3.—*Calothrix confervicola* Ag. A fasicle of filaments growing on an alga. An escaping hormogonium is figured at *a*. × 40.

FIG. 4.—*a*. *Polysiphonia nigrescens* Grev. Tip of frond, showing young cystocarp. × 20. *b*. Branchlet of the same with antheridia. × 20. *c*. Terminal branch with tetraspores. × 20.

Explanation of Plate 51.

FIG. 1.—*Fucus vesiculosus* L. × ½. *a*. Rhizoidal portion. *b*. Tips of the frond bearing conceptacles. *c*. Air bladders. *d*. Prolifications.

FIG. 2.—Cross section of a small branch. × 190.

FIG. 3.—Median section of a conceptacle with antheridia. × 200.

FIG. 4.—Median section of a conceptacle with oogonia, the oospheres showing in some of the sacs, also the cell structure on the right hand. × 200.

FIG 5.—Fertilization of the oosphere and growth of the oosperm. × 500. *a*. The oosphere surrounded by the antherozoids. *b*. The oosperm germinating after about two hours.

of other fields. In schools it is looked upon as an ornament, in life as an amusement. The *fin-de-siècle* student considers the subject rather as a flourish or ornament to his education, adding something of finish it may be, setting off to better advantage the completed structure. And so he attacks the subject much like a chicken picking at a bone, neither, I fancy, has any serious thought of ever getting the best of the matter under consideration. Naturally then with misconceptions and no real knowledge of the subject, having "finished his education," if he has the temerity to again cultivate the field he invariably enters by the one road where angels would fear to tread, and begins upon a work for which not one man in a thousand has any fitness or possibility of securing any scientific knowledge. He flatters himself that in the interest of science he is counting parts and comparing outlines, but the chances are that the same motives that urge the bug from flower to flower, the caloric advertisements hung out by the plant, are the chief stimuli to his work. In attempting the problems of taxology he enters upon the most difficult field in Biological Science. One requiring not only the broadest education but natural gifts and powers that are not within the bestowal of any educator or institution. So he is fated not only to work to no purpose, but to do poor work which will be an injury to others and worthless to himself, if we except that which must accrue to his benefit from the exercise in the field. The great evil of all these conditions is that such men are looked upon as Botanists. This is all the meaning that attaches to the subject. To how many does the name signify anything more than plant analysis?

Then again we are a restless, eager people, fond of movement and things that move. The quiet subtile life, abundant and on every hand, does not appeal to us; and especially is the painstaking plodding study of it distasteful. Our scholastic character is fairly well reflected in the admonitions of the annoyed judge—he wanted silence in the court and mighty little of that. It is a matter for encouragement, however, that the importance of this side of Biology is being recognized in this country. Already some work is finding its

place among the studies of a few institutions and matters are shaping themselves to give it a recognition worthy of its importance. The writer was forcibly reminded of this some time since in speaking with the head of the biological department of an institution of which we are all justly proud. After speaking in the most orthodox manner of the relationship of the two branches of his chair and showing with pardonable pride the work in Zoology, being called upon to outline the work in Botany, he remarked that owing to the financial depression, etc., it had been impossible to establish a course in Botany on a scale at all commensurate with the dignity of the subject. He was reduced, perhaps wickedly, to the humility of confessing that the work was confined to a single term and was of an order comparable with that of a good high school. The boys heard lectures on stem, root and leaf, the formation of the seed and its germination—"the cycle of life, you know." It occurs to the writer that it is rather unjust to attribute the neglect of Botany to the financial measures of political parties.

This evening a few plants, not only the most common but also the most offensive to sight in your harbor, have been selected for discussion with the hope that the paper might gain something of advantage by contrast, and more especially that my audience might be driven by the consideration of a dry paper to seek relief in the study of one of the most interesting provinces of Botany. Perhaps no field presents more interesting problems in phylogeny, certainly none shows so clearly the forces at work under the simpler conditions of life here imposed; and truly all those questions of relationship, habitat and range, of structure and life processes lose nothing of interest among these lowly forms. Although characterized by wide morphological differences and variations in life histories, nevertheless it will be found that the simplest are wonderfully constant in their development. Much has been said concerning the polymorphism of these simple forms, and superficial observation has given much wider currency to this belief than the facts will justify. It is a common occurrence to note in apparently pure cultures the

replacement of one form by another. It should be borne in mind that evidence of this kind is of little value, for it is more than probable that spores of many forms have been gathered, and the changed environment was the condition necessary to bring into life one form or destroy another.

In this connection is of interest the recently published observations of Alexander Artari on the Protococcoideæ. In a series of observations of long duration he has observed under the microscope the growth of these minute plants. Being first sure of the purity of his cultures he subjected the plants to all changes possible, such as variations of light, heat, food, atmospheric conditions, and following them through their life histories established beyond doubt, it would seem, the constancy of sixteen species of the order, many of which have been considered very doubtful. These observations are especially noteworthy because the studies were made on unicellular plants that are probably archaic forms and especially liable to variation.

A common member of the summer flora of the harbor is found on the larger algæ or in patches on the rocks giving a dark bluish green color to the substratum. The fasiculate tufts, the filaments terminating in a hyaline hair, and provided at their bases with one or more conspicious cells, heterocysts, render easy the recognition of this microscopic plant. The *Calothrix* belongs to one of the simplest groups of plants. In morphological characters and life processes it often closely resembles the bacteria. The cysts of the filaments can hardly be spoken of as cells, for they contain neither a nucleus in the common acceptance of the word, nor chlorophyll; while the mucilaginous character of the cell wall renders difficult its sharp separation from cell contents. The lowly condition of the plant is indicated by the general diffusion of the chromatic substance through the cytoplasm, and by the absence of chlorophyll and consequently of starch, also by the distribution of the nuclear substance and the absence of distinct organic substance in wall and cell contents. In fact every feature of the physiology points to a very primitive stage in the evolution of plant life. None the less simple is its growth and

propagation. Any of the cells may divide to increase its length. Multiplication of species, so far as observation teaches, is only accomplished by the escape of a few cells of the filaments and, after a period of rest, these grow into a new plant. It is reasonable to expect that propagation is also effected by the rejuvenescence of a single cell and spore formation. In *Calothrix confervicola*, the plant common with us, I have seen no indications of this. There are no sexual processes.

At many places along the beach, where there is shore drainage, or between the tides, will be seen brown slimy patches on the mud and rocks, and scarcely can a plant or stick be removed from the water without giving the same slimy feel and affording myriad examples of another and the most common plants in the harbor, the diatoms. I am not so presumptuous as to offer to a microscopical society any facts on diatoms, but introduce these much observed plants as one factor in the biological series under consideration. Their life history, though simple, presents a decided advance over that of *Calothrix*. Although no plants have received so much study, nevertheless there remains much to be determined concerning the minute structure of the cell. However certain known features of the gross anatomy, such as the nucleus, chromoplasts and starch indicate clearly that we have arrived at a much higher horizon in life. They commonly multiply by vegetative propagation. The two overlapping valves of the frustule draw apart, the cell contents divide, and the two old valves separate entirely to form each a new valve, covering the exposed portion of its cell contents. This new valve fits within the old, so that with each succeeding generation must be associated a reduction in size, for owing to the silicified valves no growth in length can occur. When a minimum size has been attained a return to their original greatness is effected in a variety of ways quite in keeping with their simplicity. The common and probably the *sui generis* method comprises four stages arranged about as follows: the casting off of the valves, growth of the naked cell, secretion of a cellulose coat, and when the maximum growth has been attained the formation of silicious valves within the

cellulose wall. Sometimes, as if under the influence of habit, the second stage is varied by a bipartition. A common mode of propagation is very suggestive of conjugation. Two cells arrange themselves side by side, become enveloped in a gelatinous mass, and, with the discharge of their valves, the two naked cells behave in their growth as noted above. In the last and highest form of multiplication of species to be noted we find a reproduction process. The early stages resemble the previous method, but the life cycle is completed by the mingling of the two naked cells to form a zygosperm. Thus we see that the advance is more pronounced in the processes of propagation and reproduction than in morphological characters. For, although there is an unmistakable tendency among these unicellular plants to become filamentous, on the other hand the diatom rises from purely vegetative and asexual to sexual methods. Sex, however, has not been established. An interesting question here presents itself to the members of the Society—whether we are to consider the third case simply as an asexual propagative method, as in the first and second examples, or have we a case of parthenogenesis? The former seems to me to be the more natural supposition. In the diatoms we are dealing with the lowest members of a natural group, and by gradual changes are to be evolved the more complicated processes.

If one thing stands out clear above another to the botanist, it is this fact that he is dealing with life that is writing over and over for his dull understanding, in varied form to be sure, the same history. Each natural group repeats the tale. This life has pushed out in its ascent along many lines, attaining a higher or lower horizon in each group, according as the plan or method of the particular scheme followed was of advantage or not. Little advantage can come from speculating upon the probable ancestors of a particular form, as compared with a study of its immediate connections. Here is a trend along which life is developing. Not so much importance then the character of the ancestors, for their offspring were sports, and these and their remote surviving descendants are subject to new laws, in fact are proceeding along new

lines, and naturally reveal more of truth about themselves than their ancestors.

It is a disputed question, however, whether we have an example of rejuvenescence or apogamy, whether we have an approach to sexual processes, or an illustration of retrogression.

Another plant more conspicuous from its size and nearly as common, covers the wood work and stones between the tidal limits with a grass-green coating. The *Ulothrix* consists of a single chain of cells that possess intercalary growth. These vegetative characters we saw foreshadowed in the bipartition and tendency to form filaments among the diatoms. This form is of interest to us because it illustrates a decided advance in reproductive processes. Any of the cells may increase in size, and by the segregation of the cell contents, small ovate naked bodies are formed that escape through the ruptured wall. These zoospores are rendered mobile by four cilia, and after various journeyings attach themselves by the jointed hyaline end, the root portion, withdraw their cilia, secrete a cell wall, and by subsequent transverse divisions form a new plant. It is of interest to note this early appearance of the root. The basal cell differs little morphologically from the other cells save in its lack of chromatophores. Several adjoining cells usually are changed more or less in character, and all become with age somewhat irregular in form and more or less colorless. This primitive root has only acquired the lesser portion of its functions. It plays no part in the economy of the plant other than that of an anchor. The important function of absorption is yet to be acquired. Similar but smaller and biciliated bodies are also formed in the vegetative cells, and these are of especial interest. They may have a similar life cycle to that just noted, but it is worthy of note that the resulting plant is not so large as the one produced by their larger relatives. However, after emerging from the cells two may conjugate and, after a somewhat complicated series of changes, give rise to a new plant. Although asexual propagation is still common, sexuality has become clearly established. Furthermore, it will be noted that while these

gametes are externally similar, still it is not to be doubted that sexual differences exist among them. Strasburger has always maintained that the sexes are equivalent and has attempted to show that in the mingling of the gametes in the plant world there is no extrusion of the polar bodies, emphasizing his statement by his recent magnificent demonstration of the reduction in the number of the chromosomes in the nuclei of the gametophyte, as compared with the number in the nuclei of the sporophyte. It is easily imagined that this is no small solace to one who has always maintained that the so-called sexual characters are simply external adaptations to ensure conjugation, and that now no further argument is necessary to establish the physiological identity of the sexes. For my own part it seems to prove nothing of the kind. We have gained one step in the *modus operandi* of life processes, nothing as to the nature of the process. Why must the conjugating gametes be derived from two cells if the sexes are equivalent physiologically? If conjugation is not effected, why are they unable to form a new plant at once like the larger zoospores, but must needs wait till something apparently has been added to them before a new vegetative growth is possible? However, with conjugation two complimentary bodies have mingled, and now no time need elapse for gaining strength before a new growth will ensue. It should be added that the zygosperm passes through a period of rest, as is usual in all cases of this kind; but first comes a root growth by which it is attached to the substratum. But one reasonable explanation can attach itself to the behavior of these bodies. The smaller ones have suffered some loss that incapacitates them for immediate independent growth. It would appear evident that some had lost certain vital elements, and that others had retained these elements to be deprived in turn of others, and that it is just such distinctions that constitute sex. External form signifies nothing as to the nature of the object, although naturally nature and external characters will be associated. So the mingling of these two bodies, externally similar, brings all the elements necessary to growth, and without this fusion time must elapse sufficient for the building up of the missing

factors of growth. In the case of the zoospores, however, the elimination of necessary material has not been suffered, and immediate growth follows.

Another familiar plant forms soft yellowish brown masses, either floating free or attached to water plants. In the *Ectocarpus* we note an advance over other forms in the excessively branched filaments, but again chiefly in its reproductive characters. While the growth of the filaments is intercalary, it is largely relegated to definite lower portions, and the distribution of labor is more manifest in the setting aside of the cells in the continuity of the branches for reproduction and propagation. Perhaps, however, in the septation and specialization of one of these vegetative cells for the formation of gametes, that behave much like those noted in *Ulothrix*, we find the most significant advance yet noted. And, again, in the conjugation of these similar gametes it has been observed, in some species of the genus, that one retains its mobility longer than the others. In the shorter mobile period of one of the gametes (female) we have the simplest observable differentiation of sex. In some species the sexes are recognized by their size.

Passing now to the rockweed that renders unseemly so many places about the harbor, we first are impressed with the rise in importance of vegetative characters. Externally we have a segmentation into root, stem and leaf, and physiologically this is also true. The root is simply a disk exercising but one of its functions. The thickened rounded portion finds its homologue in the stem of the tree, while above the broadened wings expose, as surely as a leaf, the chlorophyll pigments to the light. In the anatomy of the plant we note considerable differentiation of tissue and corresponding distribution of labor. A clearly marked epidermal zone with prolonged growth thus filling the place taken by the phellogenetic meristem. Beneath this rind the cells produce lateral outgrowths, ramify the central portions of the stem, and suggest a cambium zone, an analogy not so remote when we consider some of the larger allies, and finally in the centre extend the elongated cells of the medulla, the forerunners

of the basal strings. With this outline in the phytotomy of the *Fucus* let us pass to the reproductive parts. These are located in cavities at the tips of the branches and mark the consummation of reproductive processes in this line of ascent. Asexual propagation has been entirely replaced by the sexual. Definite portions of the plant are now devoted to the formation and protection of the highly specialized organs. The species under consideration is diœcious, securing the advantages of cross fertilization, and the sexes are clearly marked. The female cell, oosphere, has lost the power of motion, as was hinted at in *Ectocarpus*, while the male, antherozoid, remains mobile. With the escape of these bodies from the mother cell the oospheres will soon be seen to slowly rotate owing to the large number of antherozoids that become attached to them. After about an hour one of the gametes has mingled with the oosphere, when a cell wall is formed and, without a period of rest, the oosphere begins to develop a new plant.

There remains but one step in advance to complete the plan of growth resorted to in the plant world. Along the coast at low tide will be found a good illustration of this stage. The *Polysiphoniæ*, though not presenting such gross vegetative characters as the *Fucus*, in their growth, ramifications, and cortications, are as highly differentiated, while in reproductive characters, though belonging to the "submerged tenth," nevertheless afford a glorious prophecy of the plans that are to be resorted to among their more exalted relatives, though two grand epochs must intervene to see them fully worked out and realized in the flowering plants. To cut short this too long paper, only a few points in reproduction will be noted. We have at last arrived at a point, indicated almost in the beginning, where the propagative and reproductive parts are no longer mobile but dependent upon the currents in the water for propagation, as are the Phonerogams upon the wind, and, as in the seed plants, so here the female cell never leaves the gametophyte. In fact, we cannot speak of a female gamete. The cell that receives the stimulus of the male cell is an undifferentiated cell. The contents of the male cell is trans-

mitted through an apparatus strongly suggestive of stigma, style and ovary, but by a process quite unique in biological science propagative bodies are formed. We can neither speak of the process as conjugation or fertilization. There is no fusion of equivalent gametes or impregnation of an oosphere, and of course no zygosperm or oosperm results. The receptive, undifferentiated cell seems simply, to be quickened into vegetative life, a process that usually attends pollination among vascular plants. After a considerable growth spores arise in some of the ultimate cells, and the whole growth becomes inclosed by a cortication that springs from the lower surrounding cells.

The reader will, of course, understand that no natural sequence has been attempted, but rather a few of the salient points of our most common and unattractive plants have been touched upon, to illustrate the facts that are easily within the range of any observer.

I am indebted to Mr. F. Emil for the illustrations.

THE RELATION OF APERTURE TO THE DETERMINATION OF MINUTE STRUCTURE.

BY CHARLES F. COX.

(*Abstract of a Paper read February 15th, 1895.*)

The central idea of Prof. Abbe's theory of microscopical vision is that, for the eye to perceive a true image of an object, all light rays from that object must be gathered up and transmitted by the objective and recombined at its back. He formerly held that there was an essential difference between refracted and diffracted rays, and that there were two distinct images formed by them. But he has more lately reached the conclusion that there is no difference in principle between the rays, and that, as a matter of fact, there is but one image-forming process, which is diffractive. The rays upon leaving an object are supposed to be dispersed at all angles from the direct axial line up to the maximum of 90°, so that, to receive and completely combine them, we require a lens of 180° aperture in the medium which surrounds the object. Every object, however, is composed of large parts and small parts, and it is a deduction from the theory that the angle of diffraction for any ray is in inverse proportion to the size of the element or detail of structure from which it emanates, so that for a coarse structure the dispersion will be confined to a relatively slender cone of light, which may therefore be taken up and recombined by a correspondingly narrow-angled objective. The lens will in such case produce a truthful image. But the dispersion becomes greater with finer details of structure, and in order to admit the rays from them the aperture of the objective must be proportionally widened.

Owing to the complexity of the modern objective available aperture is much less than the theoretical. The measure of the former is, in practice, "the ratio between the utilized diameter of the back lens and the focal length of the objective," that is to say, the proportion of back lens which can be filled

with image-forming light. Assuming that the total area of the back lens is in accordance with calculation for the combination to which it belongs, the available area, in the case of an apochromatic, is generally conceded to be about seventy-five per cent. Consequently, although objectives are made with the full theoretical aperture of 180° in air, and of something more than 161° in oil, none of them is capable of projecting from its back lens anything like the whole of the rays which leave the object and which appear to be taken in by the front lens, and so all our finest optical combinations must inevitably, according to the diffraction theory, fall far short, not only of an ideal performance, but even of their calculated efficiency. Accordingly, Prof. Abbe has propounded the doctrine that no known method of construction can produce an objective capable of giving a true image of any structure composed of parts which are closer to one another than within the $\frac{1}{2500}$ of an inch, and, as an example, it is declared that "our finest homogeneous objectives of greatest aperture invariably fail to reveal to us the real structure of the finer kinds of diatom valves."

It is a further deduction from the diffraction theory that an oblique illuminating pencil, by throwing a part of the base of the inverted cone of light from the condenser beyond the angular grasp of the objective, must be fatal to a correct image, particularly with a condenser having a practicable aperture equal or close to that of the objective. It is therefore the teaching of Prof. Abbe and his followers that "strictly similar images cannot be expected except with *central* illumination with a narrow incident pencil, because this is the necessary condition for the possible admission of the whole of the diffracted light."

The facts just stated raise two important questions: (1) Why should we continue the use of high power objectives in biological and morphological investigations, after being told that in the very nature of things they cannot give anything but false answers to our inquiries; and (2) why should we spend our money upon, and perplex ourselves with, wide-angled sub-stage condensers, since the highest authorities

have declared that they only add to the perversions and misrepresentations of the objectives?

As to the first question, it is quite evident that we do not believe the statement upon which it is founded. This is plainly one of the cases in which we go on repeating the orthodox creed while qualifying it by some secret mental reservation. But if our apochromatics cannot possibly tell the truth as to minute structures, are we not bound to discard them in our investigations of such structures? Or, if we persist in their use and continue to believe in their revelations, should we not give some consistent and reasonable explanation of our adherence, at the same time, to the so-called diffraction theory of vision? My object is not so much to state my own position, which is of little importance, as to reopen the general question for debate. I am free to say, however, that I am one of the unconscionable heretics who place more or less reliance upon what is seen through the modern high-power objective, and who still cling to the belief that the image at the back of the combination affords some safe criterion of the structure of the object lying in front of it.

* * * * * * *

We are all familiar with the striking experiments devised by Prof. Abbe to prove that the so-called diffraction spectra are necessary to the formation of an image, and that their inclusion or exclusion by means of stops at the back of the objective determines the form of the image.

(Diagrams of these appearances thrown upon the screen. See Carpenter, 7th Edn., pp. 67, 68, 69.)

Now all this is very interesting and, in a way, instructive; but are we not too much disposed to jump to the conclusion that we have here proof that all images seen through our high-power lenses are illusory? Let me ask when do such conditions occur in actual work? In our usual investigations we never employ any such stops as you have just seen figured. We do, however, use objectives in which varying proportions of the back lens are covered with image-forming light,—in which, therefore, we have conditions nearly equivalent to

using stops with single central openings of different diameters. If no glass can give a correct picture of any element less than the $\frac{1}{2500}$ of an inch in diameter, it is difficult to see what interest attaches to the effect of more or less aperture in high-power objectives except from the side of mere physics, since one false image is no better than any other false one, for purposes of morphological investigation. If, however, every increase of angle is a distinct gain, as we are taught to believe,—if every step towards the attainment of the maximum aperture is a step towards absolute truthfulness in the image,—it would seem as if a progressive reduction of opening should result in wider and wider divergence from faithfulness in the image. But experience does not confirm this inference, for, having once secured resolution of a lined object with a well-corrected wide-angled lens, we may stop it down to a very small fraction of its original aperture without at all falsifying the image. As we diminish the back opening of the objective we continue to see exactly the same parallel lines as long as we can see any distinct image whatever. In illustration of this fact I show a set of photographs of the Abbe diffraction plate, made by Mr. T. F. Smith. They were taken by an apochromatic of 1.40 N.A., and begin with a picture made when as nearly as possible the full aperture of the objective was utilized. Then they show successively the effect of using a stop with a $\frac{1}{12}''$, a $\frac{1}{20}''$ and a $\frac{1}{32}''$ opening, and you will observe that they confirm the statement I have just made, and seem to prove that, under ordinary conditions and within the limits of their resolving powers, our objectives do not play tricks with the forms of objects.

It is because such demonstrations as this tend to increase our faith in the general trustworthiness of our lenses that biologists continue to pursue their investigations by their aid, and to eagerly seek after every new development of the optician's art. It is not because they believe that any existing objective is capable of revealing the very ultimate structure of an object, but because they have, notwithstanding the discouraging doctrines of the theorists, a lingering belief that the revelations of our instruments are honest as far as they go.

If a narrow-angled lens produces a truthful image of a coarse object, may not a glass of a larger angle present a correct representation of the somewhat finer parts, and a really wide-angled objective give us an accurate reproduction of very minute details? Admitting that such may be the case does not preclude a belief in structure still invisible. Nor does it necessitate the belief that every appearance we now perceive is within the realm of truthfulness. While encouraging a general confidence in what we see distinctly, it still leaves room for question and debate as to the meaning of things which we merely glimpse or only half see.

* * * * * * *

I now throw on the screen some of Mr. Smith's photographs of diatom valves, showing the fibrillar structure discovered by him. Many of these are new, but some of them I exhibited in this place four years ago, in illustration of a paper which I then read on his behalf. After the first interest excited by his discovery, the subject does not appear to have received any attention whatever in this country. And yet, whether the appearances so clearly photographed by Mr. Smith are geometrical reproductions of an actual structure or not, their production in the microscope is a fact of importance, and a new fact for which I should suppose it was worth while to account. I, therefore, introduce these pictures now, not so much because of their morphological significance as because of their bearing upon the question of the value of aperture and the criterion of the microscope's truthfulness.

Who, in looking, for example, at the photomicrogaph marked by him No. 10a or No. 19 can, without a positive effort of mind, bring himself to doubt that it is a faithful representation of an existing structure. And how much less easy is it to doubt, when one has made a direct comparison between the original image seen in the microscope and an image of some positively known structure seen through the same lens and under the same conditions of illumination. Suppose, for instance, you place upon the stage one of Webb's specimens of fine diamond writing,—say, the Lord's prayer done in the $\frac{1}{50000}$ of a square inch,—and finding this, as you must believe,

truly represented to the eye, you merely substitute for it a valve of Pleurosigma formosum, and find upon it Mr. Smith's fibrillar layer, how are you going to persuade yourself that while the former is seen as it is, the objective must inevitably "fail to reveal to us the real structure" of the latter.

When these photographs were first exhibited before this Society, it was suggested on the one hand that the appearance of fibrils was an effect of oblique illumination and, on the other, that they could not be a real structure because they were seen only upon dry specimens illuminated by means of a dry condenser of N. A. 1, with which it was supposed to be impossible to project through the object and the cover-glass a cone of light having an angle greater than "the critical,"—*i. e.*, 82°,—in consequence of which it was assumed that the objective was practically reduced to this aperture, and could not reveal more than would be shown by any other glass of the same angle. It was held that, in order to establish the correspondence of the image with a veritable structure, the same appearance should be obtained from a specimen in balsam or other medium and under conditions favorable to the utilization of the full aperture of the objective.

Regarding the first point, I can testify from personal observation of Mr. Smith's methods and from a repetition of them with my own apparatus, that the appearances presented in the photographs are obtained with illumination as nearly central as it can be made, although, of course, I am aware that, even when the condenser is carefully centred, the result of the use of a very broad cone of light, such as Mr. Smith employs, may be the introduction of more or less oblique illumination, particularly if the object is not exactly at the focus of the condenser, which seems to be necessarily the case when the condenser really has an aperture close to 180° in air and is worked through a thick glass slip. I have found, however, that the condenser may be stopped down almost indefinitely, by closing the iris diaphragm, without altering the general appearance of the fibrils, and that no such change is produced by shifting the light from the centre to the side as would occur if the image were a mere "ghost."

As to the criticism that the value of a large aperture in the objective is neutralized by its use upon a dry object, I think that, if we are warranted in considering the specimens photographed by Mr. Smith as really "dry," the answer is to be found in the principle expounded on pp. 58 and 59 of the last edition of Carpenter, where it is shown that under the conditions we are considering the objective works as a dry lens of 180° theoretical aperture, and is consequently capable of receiving the light from a condenser of the same angle. It seems to be the case, however, that thus far these fibrils have been seen only upon valves which are in close contact with the cover, to which they have been attached by heat, and it is therefore probable that the surface under observation is not in air at all, but is rather imbedded in the glass. If so, the fibrillar layer is practically mounted in a medium having a refractive index of 1.52, and we have in reality a perfect continuity of homogenous immersion. Mr. Smith, as I understand it, entertains the idea that the fibrils are obliterated in balsam by reason of the approximation of their index of refraction to that of the mounting medium, but if this were the true explanation they should be invisible when imbedded in glass as I have imagined,—crown glass and balsam having substantially the same index. On Mr. Smith's theory, too, the fibrils must have a higher index than that of the silex of the body of the diatom, which is only 1.43. On the contrary, it seems to me more probable that the fibrils are less silicious than the rest of the valve and have a lower index of refraction. But, assuming that they are of the same density as the main part of the valve, their visibility when imbedded in the glass might be accounted for by the difference between the index of crown glass (1.52) and that of silex (1.43). In that case, however, they ought to be visible in any other medium having a refractive index of 1.52 or more. But independently of the considerations already named, it has occurred to me that possibly the mere process of burning the valves may work some physical change which brings the fibrillar structure into bold relief, and it would be a test of this hypothesis, as well as of the others referred to, if valves upon which the

fibrils have been seen could be removed from the cover-glass and mounted in balsam and other media, and if at the same time other specimens were subjected to the burning process upon platinum and then so mounted, and if still others cleaned in the usual manner, but not burnt, were mounted in media having indices not less than that of crown glass. A comparison of preparations made by these several methods ought to settle the question as to why the fibrils are observable only on so-called dry specimens attached to the cover-glass by burning. Apropos of the suggestion I have made above, as to the effect of heat, Mr. Smith has expressed the belief that the separation of the layers, and their consequent visibility, is due mostly to disintegration of the structure some time after the diatoms have been mounted, and he thinks it is easy to see how this can happen in a dry mount and not in a medium which becomes solid.

The ability of an objective to separate superimposed structures is a matter to which Mr. Smith very properly attaches much importance, and the only doubt about his position is as to whether he does not regard this separating power as too exclusively a correlative of numerical aperture. We are, of course, all familiar with the fact that the microscope magnifies not only the superficial area of an object, but also its thickness,—its depth dimension as well as its length and breadth. In fact, the capacity of the instrument is much greater in this direction than in the direction of the two dimensions usually taken as the measure of its power. We must not, however, confuse this with depth of vision, or penetration, to which it is in fact diametrically opposed. In the proportion in which we magnify the superficial diameter of an object, the objective includes less of it in the field of view. So, the more we magnify the depth dimension, the less of the object's thickness are we able to see at one focus. For this reason the objective becomes what has been aptly called "an optical microtome," and this microtome cuts thinner and thinner sections as the magnifying power of the objective increases. But it also separates layers which are closer and closer together as the angle of aperture widens. We need to remember, however,

that this power of differentiation is as the square of the lineal magnification on the surface, while it is only in direct proportion to the angle of aperture. It is, therefore, vastly more dependent upon power than it is upon aperture.

Mr. Smith has provided us with some interesting photographs (which I now exhibit) showing several diatom valves, first with an old-time water-immersion $\frac{1}{12}$ (the aperture of which he has, however, unfortunately omitted to give us) and then with a recent oil-immersion apochromotic $\frac{1}{12}$ of presumably N. A. 1.40, and the contrast is certainly very striking and wholly in favor of the wider-angled glass. Nevertheless it does not appear to me that we are forced to the conclusion that the improvement in the image is due wholly to the increased aperture of the lens. We must not overlook the fact that the apochromatic system permits of a perfection of correction never reached in any other form of lens, and we must not omit to give this matter its due credit for the clearer definition of the object, and even for the disclosure of details not before perceived. In some of these photographs I confess the superiority of those taken with the apochromatic seems to me due more to the elimination of spherical and chromatic aberrations than to the mere increase in numerical aperture.

At any rate, in comparing lenses with reference to their ability to determine minute structures we ought to take into account three factors, namely, power, aperture and corrections. Neither one of these will account for the result. Aperture is an addition to power, but neither is useful without delicate and accurate corrections. The lenses made before the introduction of the homogeneous immersion and apochromatic principles had ample power, but we were all puzzled to make out why it availed so little. The one-fiftieths of that day were not as serviceable as one-sixths, or even some one-quarters, of the present time,—partly because they were deficient in aperture, but still more because of their confusing and baffling aberrations. Mr. Smith's photographs show that with the Powell & Lealand water-immersion lenses of twelve or fifteen years ago it was not impossible to sepa-

rate thin layers so much as it was to get a clear image of details in the plane where the objectives worked best. It was not because they had too much penetration, but because while they were weak on the side of resolution, due to lack of angle, they were particularly faulty in the matter of definition, because of their want of correction. I certainly do not mean to say that the production of wider apertures has not added to our ability to see new details. I am merely emphasizing the fact that the invention of the apochromatic principle has made such corrections possible that we are now able to utilize both powers and apertures which were previously of no advantage. At the same time it is worth while to insist upon the fact that Mr. Smith's fibrils are by no means beyond the reach of comparatively low powers and narrow angles, as far as their dimensions are concerned. In fact they are of such a size as to be easily seen by means, not only of simple achromatics of fifteen or twenty years ago, but also of recent one-fifths and one-quarters of numerical apertures much less than 1.0, provided the fibrils are separated from the valve and lie where they can be observed without confusion with any underlying structure. It is when the fibrillar layer is *in situ* that the superiority of the widest-angled lenses becomes evident, for it is then that extreme shallowness and delicacy of focus become effective.

Every increase in numerical aperture will, in my opinion, disclose to us truthful images of structures finer than any pictured to the eye through smaller apertures, provided increase of power accompanies increase of aperture and perfection of correction goes along with both. There is plainly a correlation between the angle of aperture of the objective and the angle of diffraction of the object. Supposing, for illustration, that lines lying within the $\frac{1}{50000}$ of an inch of one another, in air, disperse ordinary white light to a maximum of 62°, and that lines lying within $\frac{1}{100000}$ of an inch of one another similarly disperse light to a maximum of 147°, then an objective having an air angle of 62° (N. A. 0.52) will give a truthful image of the former, but not of any finer lines, while a lens having an air angle of 147° (N. A. 1.04) will cor-

rectly represent the latter as well as lines intermediate to these and the others, or coarser still. If, therefore, we had under the microscope a structure composed of elements, part of which were $\frac{1}{50000}$ of an inch in diameter and part $\frac{1}{100000}$ of an inch in diameter, a lens of N. A. 0.52 would reveal the former, and not the latter, but would be absolutely truthful up to the limit named. On the other hand, the lens of N.A. 1.04 would correctly image the finer as well as the coarser parts of the structure up to diameters of $\frac{1}{100000}$ of an inch, while leaving us totally in the dark as to what elements of structure might exist beyond this maximum of its resolving power. It therefore seems to me that Mr. Nelson was in error when he said: "The logical conclusion, granting the Abbe theory to be correct, is that all microscopic diffraction images are false."

* * * * * * *

The fact appears to be that the best wide-angled oil immersion and apochromatic objectives accomplish better results even in fields where lower-powered and smaller-angled glasses have hitherto been supposed to be all sufficient. In the formation of what have been considered purely dioptric images they are not less satisfactory than in the disclosure of strictly diffractive effects. Except for use with the Wenham binocular, with which a narrow angle is a *sine qua non*, they seem, in short, to cover the whole ground of microscopical research better than any other existing lenses, and their invention was therefore not merely the addition of a new variety of objective to the general class, but rather a distinct advance in the evolution of the class itself.

* * * * * * *

It is, of course, necessary in estimating the performance of an objective to take into account the character of its illumination, and we cannot consistently consider the refinements of optical science and art which have been devoted to the lenses above the stage without also devoting attention to the improvements which have been made in and the ingenuity which has of late been expended upon the sub-stage con-

denser. Space will not, however, permit my dealing with this subject in detail. Still it seems necessary to remark that the main question now open for discussion with regard to condensers is whether they should transmit a narrow or a broad cone of light and whether the aperture of the condenser should approximate to or match that of the objective. Mr. Nelson has been the leading advocate of the wide-angled condenser and long ago announced the theory that if the angle of the illuminating cone equals that of the objective the image will be a true one, and I think it is mainly to the weight of his authority that we must attribute the demand for apochromatic condensers running to 1.40 numerical aperture and above. But Mr. Nelson also at one time advocated oblique illumination in preference to central, and Prof. Abbe has since condemned both this and the broad illuminating cone as inconsistent with the diffraction theory. If, as the diffraction theory assumes, image-forming rays are given off by very minute objects at all angles up to 180°, without regard to the source of illumination, it is not easy to see how in their case a wide angle in the condenser can favorably affect the result, except in the matter of a greater *quantity* of light. Although Dr. Dallinger, in the last edition of Carpenter, quotes Prof. Abbe's opinion against the wide-angled condenser, apparently with his own endorsement, he subsequently declares himself in favor of the theory that for "ideal" illumination with transmitted light it is essential that the illuminating axial cone should be approximately equal to the aperture of the objective used. He nevertheless admits that under such conditions of illumination the objective "breaks down," and that in actual practice we must be content to sacrifice the ideal, and, to get the best results, must make use of a cone of light only sufficient to fill three-quarters of the back lens of the objective. With condensers, as with objectives, effective aperture is much less than the theoretical, and this fact suggests the query: Why should we go on preaching an "ideal" that is not attainable in practice nor confirmed by experiment?

* * * * * * *

PROCEEDINGS.

Meeting of March 1st, 1895.

The Vice-President, Dr. Frank D. Skeel, in the chair.

Twenty-seven persons present.

OBJECTS EXHIBITED.

1. Sections of egg of the frog: by G. W. Kosmak.
2. The same, in advanced development: by G. W. Kosmak.
3. Transverse section of the skin of the lizard, *Anolis*, showing the layers and pigment cells: by L. Riederer.
4. Various insects in gum copal: by George E. Ashby.
5. Specimens of gum copal to show varying surfaces: by George E. Ashby.
6. Various insects in amber: by Frederick Kato.
7. Insects in gum copal: by Frederick Kato.
8. Hemipterous larva in amber: by James Walker.
9. Various insects in amber and copal: by James Walker.
10. About 100 specimens of insects of different orders in copal and amber: by Dr. Daniel S. Martin.
11. Ants in amber: by Frank D. Skeel.
12. A large, perfect butterfly, spreading two and one-quarter inches, in amber: by Frank D. Skeel.
13. Various insects in amber: by Charles S. Shultz.
14. Minute fly in amber: by F. W. Leggett.
15. Various insects in amber: by F. W. Leggett.

The session was largely devoted to the exhibition and discussion of insect inclusions in fossil gums, of which there were displayed about 177 specimens. Prof. Daniel S. Martin, Ph.D., exhibited about 100 specimens from his large collection, answered many questions of members and gave valuable information on the subject. He referred to the nature of the deposits of the Zanzibar gum copal, this having its origin from the tree, *Trachilobium mozambiqueense*, the fossil gum belonging to the quarternary; to the difference between this and amber, found mainly on the north coast of Germany,

having its origin in the resin of conifers, and belonging to the early tertiary; to the occurrence of fossil gums in the State of New-Jersey (Keyport and some other localities), found with lignite, of greater hardness than amber, and belonging to the cretaceous; and to the arrested decomposition of the insects enclosed in these fossil gums, instancing his possession of two specimens of large termites in African copal—one of these specimens being accidentally broken, the fracture passing directly through the enclosed insect, and a strong, unpleasant odor being immediately emitted.

Mr. Ashby mentioned several of his interesting exhibits: a dense layer of ants; a spider in close proximity to a fly, giving unmistakable evidence of the chase interrupted by the death of both parties; the streaming of scales from the wings of a struggling moth; a worker termite with a large movable bubble enclosed in liquid in the abdomen; and a curious minute hymenopterous insect, with all four wings reduced to mere clubs, each wing being furnished with large fringing bristles on both anterior and posterior margins.

Mr. Walker referred to his exhibit of a minute but remarkable insect in amber, it evidently being a hemipterous larva, with a stout proboscis passing from the head directly under the abdomen, and projecting about one-quarter of the length of the entire insect beyond the posterior region.

Meeting of March 15th, 1895.

The President, Dr. E. G. Love, in the chair.

Twenty-two persons present.

Dr. Max Myer was elected a resident member of the Society.

The Corresponding Secretary read a communication from Dr. Alfred C. Stokes, corresponding member of the Society, entitled "An undescribed species of *Vasciola* with an interesting habit." The thanks of the Society were tendered Dr. Stokes for this communication, and it is published in this volume of the Journal, p. 47.

Dr. Frank D. Skeel read a paper, entitled "Notes on the

Development of the Modern Microscope." The paper was illustrated by many lantern projections, and was discussed by the President, Mr. Riederer, Rev. Mr. Haas and Dr. T. O. Summers.

Meeting of April 5th, 1895.

The President, Dr. Edw. G. Love, in the chair.

Twenty persons present.

Mr. William B. Tuthill was elected a resident member of the Society.

The Corresponding Secretary read a communication from Mr. William A. Terry, of Bristol, Conn., entitled "A new Diatom from the California fossil deposits." This communication is published in this volume of the Journal, p. 52. In this connection Mr. Terry donated to the cabinet of the Society twelve slides of diatoms, one slide exhibiting the new diatom referred to in the communication, *Brunia Californica* Terry; one containing the forms of the Floating Fossil of Santa Monica; one containing the forms from Redondo Beach; and nine slides of Connecticut Shore diatoms.

The thanks of the Society were tendered Mr. Terry for this communication and for the donation of these slides.

Objects exhibited.

1. Sagittal sections of the upper jaw of the embryo of *Anolis principalis*, showing the præmaxillary tooth: by L. Riederer.

2. Sagittal sections of the lower jaw of the same, showing embryo teeth *in situ*: by L. Riederer.

3. Four photomicrographs of these sections: by Edw. G. Love.

4. Minerals from Bergen Hill, N. J.—Heulandite, Datolite, Natrolite, Laumontite: by Frederick Kato.

5. The diatom, *Cocconeis vitrea* J. Brun, from Santa Monica material: by Henry C. Bennett.

6. Unknown parasite, found burrowing near the hinge in the inner surface of the shell of a living oyster: by F. W. Leggett.

7. The shell of the oyster, with the burrow from which the parasite was extracted: by F. W. LEGGETT.

8. The diatom, *Brunia Californica* Terry, from the Alhambra deposit, California, prepared by William A. Terry: by J. L. ZABRISKIE.

Mr. Riederer explained that his sections were from an embryo of *Anolis*, extracted from the egg about one week before the natural time of emergence. The upper jaw shows the præmaxillary tooth projecting in a nearly straight line forwards from the centre of the extremity of the jaw, this tooth, which is soon lost, being employed by the embryo for splitting the egg shell. This subject was discussed by Pres. Love and Mr. G. W. Kosmak.

Mr. Kato stated the nature of his mineral exhibits; their locality—the cut of the Pennsylvania Railroad in Bergen Hill, N. J.; and the manner of mounting them in the regulation Rakestraw boxes. A discussion by Pres. Love and Mr. James Walker followed.

Mr. Henry C. Bennett explained his exhibit as follows:

"*Cocconeis vitrea* J. Brun. I found this rare fossil diatom on a slide which I mounted in 1890 from St. Monica material, and which, so far as I am aware, has not been heretofore reported as found in that deposit. It was, however, illustrated and described by J. Brun in a work entitled, 'New Species of Diatoms, marine, fossil, and pelagic,' published in Geneva and Basel, Switzerland, in 1891, as found very rare in Yedo and Szakal.

"The following is the description: 'Valves eliptical, flat and close together. Length, 0.06 to 0.07 m m. Width, 0.04 to 0.05 m m. Superior valve has interrupted, punctate, embossed, delicate striæ toward the border, and forming two lines in the direction of the median region, slightly curved and moniliform. Marginal zone always finely striated. Striæ of the poles parallel with raphe. Inferior valve with more delicate striæ dividing toward the border. Raphe and nodules enveloped in a large hyaline zone. Silica thin and brittle.'

"The superior valve of this diatom is here shown under a $\frac{1}{10}$ homogeneous immersion objective. 1.38 N. A. × 900."

Mr. Leggett explained that the creature exhibited by him was taken from the inner surface of the shell of a living oyster, which seemed to be in good condition and which was certainly of good flavor. The parasite is a thin, disc-like creature, about one-half inch in diameter, and was snugly ensconced in a cavity just adapted to its own size, the cavity having blackened surfaces, and appearing to be eroded deeply in the white inner substance of the oyster shell near the hinge.

Annual Exhibition, April 9th, 1895.

The Sixteenth Annual Exhibition of the Society was held at the American Museum of Natural History, Central Park, New-York City, on the evening of April 9th, 1895.

Objects and apparatus, as noted in the programme below, were displayed in the halls on the second floor of the Museum. Two lectures, both illustrated with projections by the superior apparatus of the Museum, were delivered in the main lecture room: at 8 o'clock by Dr. Frank D. Skeel on "The Microscope—its Construction and History," and at 9 o'clock by Prof. Albert S. Bickmore on "Recent Advances in Visual Instruction." It was estimated that about two thousand persons were present at the exhibition.

EXHIBITS.

1. A collection of apparatus illustrating the history and evolution of the microscope.

a. Part of rude microscope, on wood column. Probably German. Date unknown.

b. A rude instrument, with leather-covered tube, wooden eye-piece, brass support and stage, wooden base, and primitive fine adjustment. Date and origin unknown.

c. Culpepper Microscope, with rack and pinion movement, in pyramidal case, with accessories. About 1738–40. A second form, without accessories. Same date. A third form, with sliding movement only.

d. Cuff Microscope, with rack, pinion and accessories. About 1744–45.

e. Wilson's Hand Microscope. Made by Adams, London, with accessories. About 1746. Another form, with brass support, mirror and stage. With accessories.

f. Jones's Improved Compound Microscope. About 1795.

g. Jones's Model, by Chevallier. About 1795.

h. Small microscope, by Cary. Attached to cover of case. About 1817.

i. French microscope, on two pillars, attached to case, bull's-eye condenser on tube, rack and pinion to stage. Date unknown, but quite modern.

Exhibits a–i, by CHARLES F. COX:

2. *a.* Microscope, by Jones and Son. Latter part of eighteenth century.

b. Microscope, presented by Louis XV. to his daughter: by J. A. GRENZIG.

3. A curious microscope, called "The Traditional," 1776: by MESSRS. GALL and LEMBKE.

4. Microscope of the last century, made by George Stirrop: by DR. CHARLES E. WEST.

5. *a.* Old English microscope of the last century.

b. A form of stand recommended by the Royal Microscopical Society of London. 1866.

c. Microscope made by Grunow, New York, with substage condenser and iris diaphragm. 1872.

d. Stand of Powell and Lealand, with all accessories; *e.* Binocular microscope of R. and J. Beck, London: by DR. WILLIAM STRATFORD.

6 Microscope, by Carl Zeiss, Jena, Germany, with latest form of mechanical stage: by MESSRS. EIMER and AMEND.

7. Bausch and Lomb's "Professional Microscope": by MESSRS. BAUSCH and LOMB.

8. Stand made by E. Leitz, Wetzlar, Germany: by WILLIAM KRAFT.

9. "Congress Stands," of the W. H. Bulloch type: by E. B. MEYROWITZ.

10. *a.* Section of meteorite, Brentham Co., Kansas.

b. Antique glass from ruins of Tyre: by GEORGE F. KUNZ.

11. Chalcedony pseudomorph after pectolite: by JAMES C. GREGORY.

12. Mosquito in amber: by F. W. LEGGETT.

13. Red garnet, Almandite, trapezohedral crystals: by FREDERICK KATO.

14. Pond life. *Daphnia:* by LOUIS W. FROELICK.

15. Kidney of snail: by W. E. DAMON.

16. Hair from common mouse, *Mus musculus:* by WALTER H. MEAD.

17. Prehnite, Paterson, N. J.: by JOHN W. FRECKLETON.

18. Sections: *a.* Root of Ipecac; *b.* Root of Sarsaparilla; *c.* Tuber of Aconite; *d.* Bark of *Cascara sagrada* (true); *e.* Bark of *Cascara sagrada* (false); *f.* Rhizome of Calamus; *g.* Leaf of Digitalis; *h.* Radix of *Menispermum:* by members of N. Y. COLLEGE OF PHARMACY.

19. *a.* Ganglion cells, human spinal cord; *b.* Ganglion cells, human cerebrum: by DR. SMITH ELY JELLIFFE.

20. *Polynema ovularum:* by THOMAS CRAIG.

21. *a.* Sting and poison glands of Honey Bee; *b.* Scales of Morpho Butterfly: by R. L. DITMARS.

22. Skin of Holothurian, *Synapta inhærens:* by E. GERBER.

23. *a.* Scales of Bird-wing Butterfly, *Ornithoptera priamus.*

b. Case of specimens of *Ornithoptera:* by WILLIAM BEUTENMULLER.

24. Fish-hatching, various stages: by DOUGLAS W. CAIRNS.

25. Crystals by polarized light: by BAYARD S. CAIRNS.

26. Antennæ of various insects: by HERMANN A. LOOS.

27. *Phylloxera vastatrix:* by WALTER S. CAMERON.

28. Odontophore of mollusk, *Sycotypus canaliculatus:* by JAMES H. TUTTLE.

29. Diatom Type Plate: by HERBERT B. BALDWIN.

30. Musical apparatus of *Cicada septendecim*: by EDW. G. LOVE.

31. *a.* Circulation of blood in tail of tadpole.

b. Movement of protoplasm in cells of *Vallisneria spiralis:* by F. W. DEVOE.

32. Series of embryos of the Alligator and the Chick.

a. Alligator embryo of four days.

b. Chick embryo of four days.

c. and *d.* Older embryos of the same.

e. Alligator embryo several weeks old.

f. Section through base of head of Alligator embryo: by DR. S. F. CLARK.

33. *a.* Karyokinetic figure in male genital cell of the Lobster.

b. Type of invertebrate eye, Scallop, *Pecten:* by A. L. KEAN.

34. The soldier of one of our common Ants, *Pheidole pennsylvanica* Rog.: by J. L. ZABRISKIE.

35. *a.* *Hydra* with attached young.

b. *Salvinia natans:* by O. H. WILSON.

36. Section of ovary of Poppy: by GEORGE H. BLAKE.

37. *a.* Bladder of *Utricularia* with captured crustacean.

b. A Spider in fossil gum copal: by GEORGE E. ASHBY.

38. *a.* Hairs of Caterpillar.

b. Sea sand from Bermuda.

c. Seeds of *Gerardia.*

d. Arranged Diatoms, opaque.

e. Arranged Diatoms, transparent.

f. Mineral section, cuprite: by H. FINCKE.

39. *a.* Ammonia, primate crystals.

b. Chrysalis of Gnat.

c. Marine crustacean, *Caprella:* by E. B. MEYROWITZ.

40. Fibrolite, found in New-York City: by JOHN LAMONT.

41. Wavellite, from Steamboat, Penn.: by A. H. EHRMAN.

42. Laumontite, from Snake Hill, N. J.: by WALLACE GOOLD LEVISON.

43. Spinnerets of a Spider: by H. S. WOODMAN.

44. *a.* Arranged Diatoms.

b. Fern leaf gold crystals.

c. Sting of Honey-bee.

d. Tongue of Blow-fly.

e. Saws of Rose Saw-fly.

f. Eye of Fly: by G. S. WOOLMAN.

45. *a.* *Trichina spiralis.*

b. Proboscis of Butterfly.

c. Foot of Spider: by WILLIAM KRAFTS.

46. A projection microscope in orperation: by J. A. COLT.

47. Pond life: by W. J. LLOYD.

48. Crystals. Asparagine: by ANTHONY WOODWARD.

49. Crystals. Chlorate of potash: by J. B. SNIFFIN.

50. Eye of House-fly: by ALFRED BEUTENMULLER.

51. Crystals. Sulphate of magnesia combined with sulphate of copper: by DR. J. W. METCALF.

52. Section of seeds of Hemlock: by W. F. PROSCHWITZKY.

53. Movement of protoplasm in cell of *Nitella:* by JOHN MCCALLUM.

54. Segmenting eggs of *Amphioxus lanceolatus:* by WILLIAM LOWEY.

55. Young clams. Polarized: by H. H. WOTHERSPOON, JR.

56. *a.* Foot of embryo of Cat.

b. Section of jaw of embryo of Pig.

c. Section of embryo of Shark.

d. Section of young Star-fish.

e. Planaria, living and in preparations: by HENRY E. CRAMPTON, JR.

57. Skin of Eel, polarized: by HENRY C. BENNETT.

58. Hydroid colony, *Endendrium:* by F. COLLINGWOOD.

59. Circulation of blood. Foot of Frog: by JOSEPH C. THOMPSON.

60. Various stages in the incubation of the hen's egg: by GEORGE W. KOSMAK.

61. *a.* Section of scalp of Monkey.

b. Section of stem of Bamboo.

c. *Volrox globator*, living: by CHARLES S. SHULTZ.

62. Section of petiole of white Water Lily: by DR. CARLTON C. CURTIS.

63. Breathing apparatus of *Nerium oleander:* by E. A. ANDERSON.

64. Sphaero-crystals of inulin, from tuber of Sunflower: by CHARLES W. OGDEN, JR.

65. Odoriferous glands of Tomato plant: by I. M. RUBINO.

66. "How the Fern grows": by MISS ANNA A. SCHRYVER.

67. *a.* Crystals of silver.

b. "Rolling stones," polarized.

c. *Eozoon Canadense*, polarized.

d. Inclusion in mica: by MISS AGNES V. LUTHER.

68. *a.* Compound eyes and multiple images.

b. Flint sponge, *Astylospongia :* by J. D. HYATT.

69. The common southern Lizard, *Anolis principalis.*

a. Left foot of embryo.

b. Section of skin from neck of adult.

c. Longitudinal section of upper jaw of embryo showing præmaxillary tooth.

d. Transverse section of head of embryo: by LUDWIG RIEDERER.

70. Living Wolffia, the simplest and smallest of flowering plants, from Staten Island, N. Y.: by WILLIAM T. DAVIS.

71. Foraminifera: by CHARLES P. ABBEY.

72. Polycistina, arranged: by G. W. MULLER.

73. Minerals sometimes used as gems, shown with automatic revolving stage and polarized light. And cabinet specimens of the same.

a. Quartz, var. Agate, from Oberstein, Germany.

b. Quartz, Tiger Eye, pseudomorph after Crocidolite.

c. Oligoclase, var. Sunstone, from Norway.

d. Lazurite, Lapis-Lazuli, from Chili.

e. Microcline, var. Amazon-stone, from Virginia.

f. Labradorite, from Labrador coast.

g. Orthoclase, var. Sunstone, from Sussex Co., N. Y.: by JAMES WALKER.

MEETING OF APRIL 19TH, 1895.

The President, Dr. Edw. G. Love, in the chair.

Twenty-five persons present.

On motion the thanks of the Society were tendered to the President and Board of Trustees of the American Museum of Natural History for their kindness in granting the use of the halls of the Museum; to Mr. William Wallace and his attendants for the valuable assistance rendered; and to Prof. Alfred S. Bickmore for the able lecture delivered, all on the occasion of the late Annual Exhibition of the Society.

The President, Dr. Edw. G. Love, addressed the Society on "Micrometers and Methods of their Use." This address was illustrated by ten enlarged drawings explaining the structure and working of micrometers.

OBJECTS EXHIBITED.

1. A Leitz filar micrometer of very fine platinum wire: by CHARLES S. SHULTZ.

2. A celebrated stage micrometer, ruled on speculum metal, by Prof. Rogers: by CHARLES S. SHULTZ.

3. An antique stage micrometer: by F. D. SKEEL.

4. A micrometer by Cuff, 1746–47: by E. G. LOVE.

5. George Jackson's eye-piece micrometer, made fifty years ago: by E. G. LOVE.

6. Zeis eye-piece micrometer: by E. G. LOVE.

7. Abbe camera lucida: by E. G. LOVE.

8. Spores of *Equisetum*, showing hygroscopic movements: by FREDERICK KATO.

9. An unknown insoluble residuum from candy: by F. W. LEGGETT.

10. Connecticut coast diatoms: from Leete's Island, Beauford deposit, Morris Creek, Quinapiac Clay Pits, and Quinapiac East Side Pit. Slides prepared and donated by William A. Terry of Bristol, Conn.

Dr. Skeel, in reply to certain questions, explained the difficulty of fastening spider web cross lines in telescope tubes, and stated that very attenuated platinum wire was sometimes obtained by using fine platinum wire as a core within copper wire, drawing out both metals together through fine dies, and finally removing the copper by means of acids.

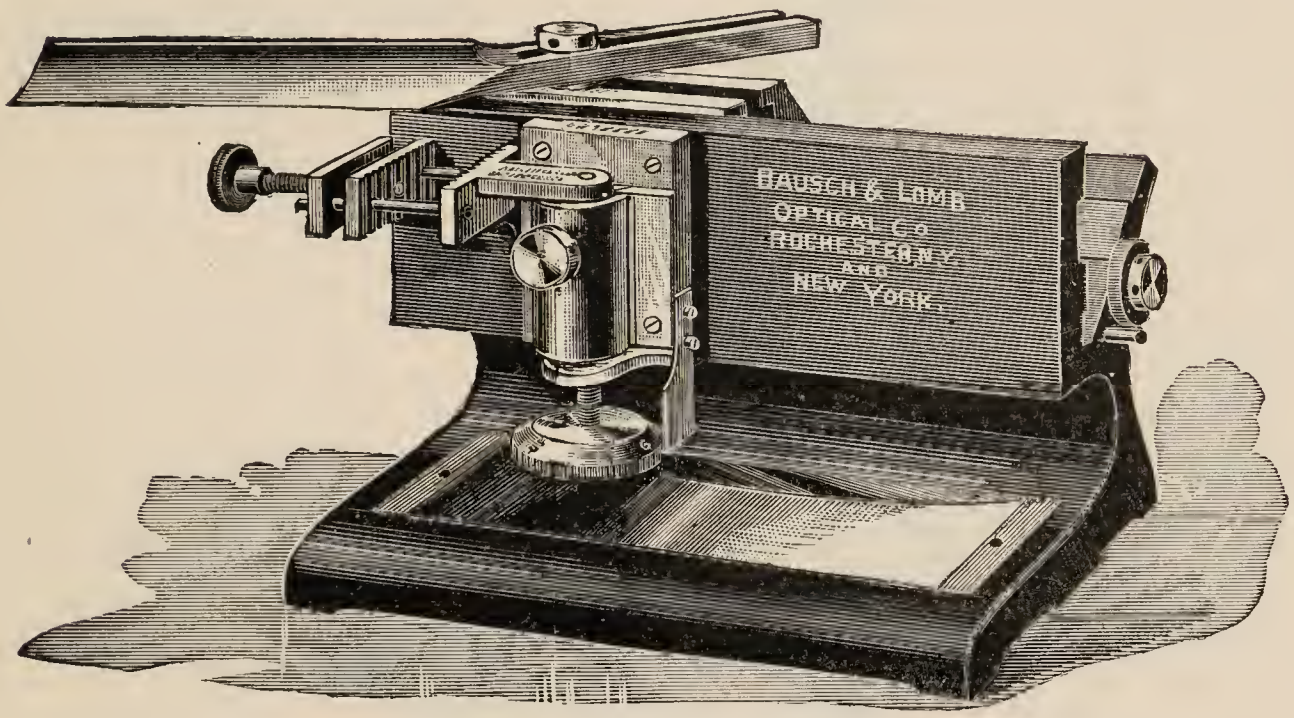
WELLCOME LIBRARY INSTITUTE

AMERICAN

Microscopes, Objectives, and Accessories

MANUFACTURED BY

BAUSCH & LOMB OPTICAL CO.



STUDENT MICROTOME, $18.00.

Do not fail to procure the 13th edition catalogue (120 pages), entirely revised, issue June, 1892, comprising **Variety of new Apparatus for the Microscopist.** It will be mailed free to any address upon application.

FACTORY AND MAIN OFFICE:

515–543 North St. Paul St.,

ROCHESTER, N. Y.

P. O. Drawer 1033.

BRANCH OFFICE:

130 Fulton Street,

NEW YORK CITY,

P. O. Box 432.

ESTABLISHED IN 1853.

JOSEPH ZENTMAYER,

OPTICIAN.

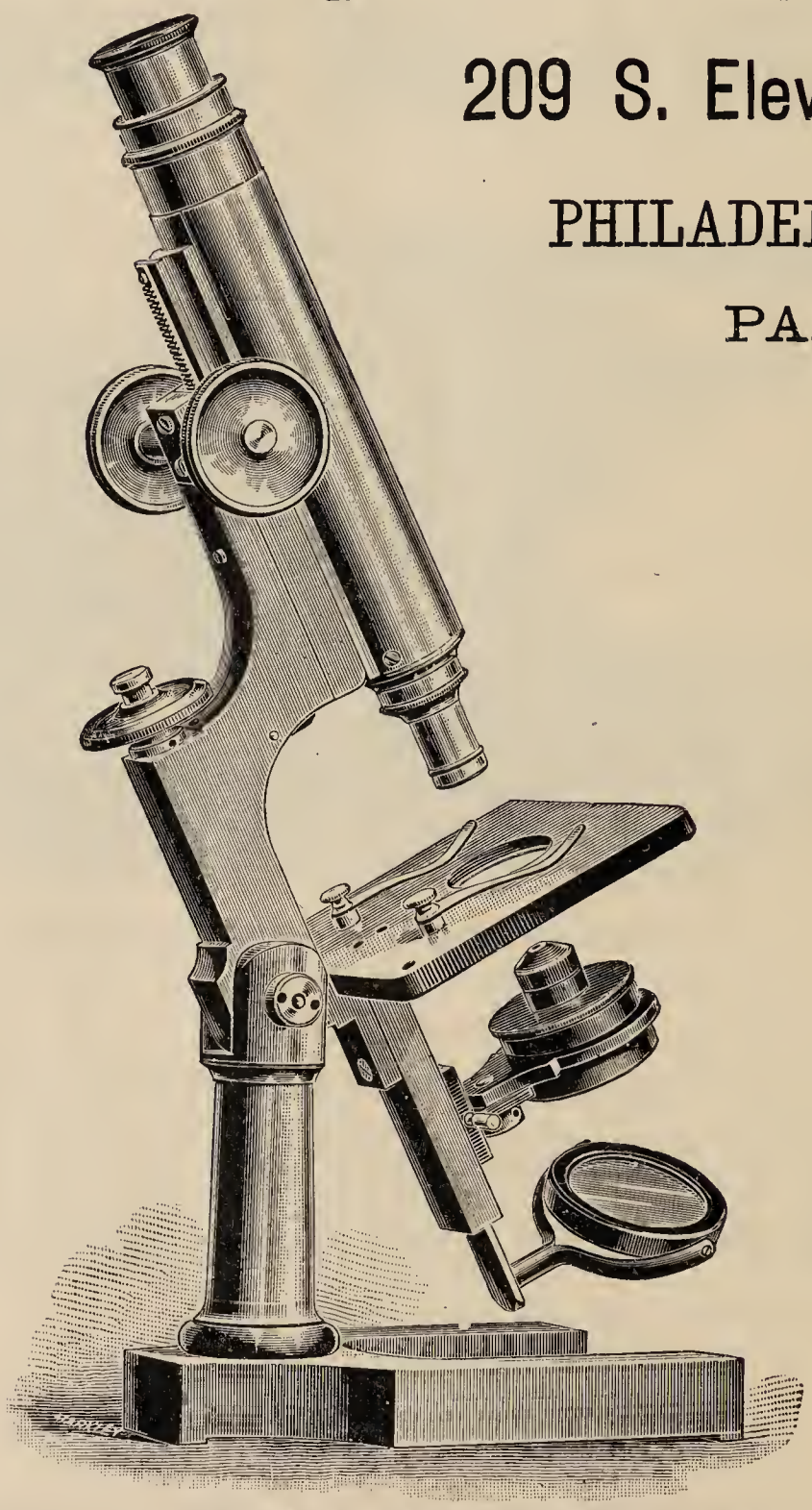
—MANUFACTURER OF—

Microscopes and Microscopical Apparatus,

209 S. Eleventh St.,

PHILADELPHIA,

PA.



ZENTMAYER'S AMERICAN-CONTINENTAL STAND.

NEW YORK AGENCY,

MEYROWITZ BROS.,

Fourth Avenue and 23d Street.

WM. WALES, FORT LEE, N. J.

SEND FOR CATALOGUE.